The Analysis of Rician PDF Integral Properties from the DSRC System Viewpoint

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***Abstract* – In this paper some statistical properties of DSRC structures, presented through the Rician fading channel model have been investigated. The approach to envelope like singular solution of the PDE, concerning the empirical conditions of PDF determining, enable to a better view on the physical process and nature of fading. The existence of singular solution could be used in the optimisation process of the *ITS* in sense of long-range prediction of the mobile fading envelope and hardware optimisation**

***Keywords* – DSCR. The Rician fading channel models, PDF, envelope, distribution, singular solutions.**

I. INTRODUCTION

The numerous statistical models of the wireless communications influenced by propagation character of the space have been developed [1-4] To provide valid performance of signal that are close to those in real situations, it is necessary to set up adequate channel model of these systems by the characteristic of the above mention statistical models. The signal envelopes and the signal phase at the receiver are the important parameters affected on the system performance. The PDF (probability distribution function) of these parameters has the different shape concerning the channel conditions, so the various types of fading could exists [5-8]. With these models not only average power level but also the maximum fluctuation of received signal can be predicted.

There are numerous services of ITS (intelligent traffic system) such as advanced toll collection, automatic vehicle control, and mobile computing and internet service are considered to be most important service in the future traffic development. Also, the *ITS* is in focus throughout the world as possible and unique measures to provide advanced and intelligent service [9-12]

The *ITS* services have been based on the DSCR (dedicated short range communication) telecommunication structure. However, along the dominant *LOS (line of sight)* component, the other numerous multipath signals are expected to arrive to antenna, so the Rician fading channel model is adequate for the *DSRC* system. Since the implement cost and high level of complexity of the user terminal is very critical point in the *ITS* services, statistical models and their characteristics, play important role.

The start point in these paper have been the numerical analyze of Rician PDF's, like particular solutions of corresponding differential equation for *K=const*., and *z=const*. in the case when we analyzed these distribution through the forms of curves family. On the other side, the envelope of curves family shows that initial differential equation has singular solution. The existence of singular solution could be used during the analysis of different conditions in the information chain with or without combiner. By the fact, that combined signal mostly treated as a deterministic process, the conclusion about singular solution could be use in the optimization process of ITS in sense of long-range prediction of the mobile fading envelope and hardware optimization in designed process of OBE (on board equipments) and RSE (road side equipments) units.

II. ANALYSIS:

The Rician fading channel models consider that the dominant wave can be a phasor sum of dominant signals, e.g. the LOS component and sum of multipath signals. This combined signal is then mostly treated as a deterministic (fully predictable) process. The wave components can also be subject to shadow attenuation.

The channel transfer function can be expressed as impulse response function $h(t)$:

$$h(t) = \delta(t) + \alpha e^{j\phi\delta(t)} \qquad [1]$$

The first item of the right side means LOS component and second presents the sum of multipath signal with amplitude α and phase ϕ. The amplitude of the multipath components has Rayleigh distribution with $E[\alpha^2] = 2\sigma^2$.

Let A^2 denote the power of LOS component, $2\sigma^2$ is a power of multipath components, then the Rician *K*-factor [3] *i.e.* the ratio of the LOS component signal power to the reflected interference power can be expressed as:

$$K = \frac{A^2}{E[\alpha^2]} \qquad [2]$$

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The starting assumptions about dominant line-of-sight component and a set of reflected waves, modeled as a phasor addition of signals with random amplitude and phase, lead to Gaussian Inphase and Quadrature component, and corresponding Rician amplitude. When the *LOS* signal component power tends to zero subsequently *K* tends to 0, the Rician PDF approaches to Rayleigh PDF. For large *A* the Rice distribution approaches a shifted Gaussian distribution centered at $z=\sigma$.The PDF dependence of the Rician factor *K* [3] could be expressed like:

$$p_z(z) = \frac{2z(K+1)}{\Omega} e^{-K-\frac{(K+1)z^2}{\Omega}} I_0\left(2z\sqrt{\frac{K(K+1)}{\Omega}}\right) \qquad [3]$$

where is Ω, the mean power of envelope, and ***z*** is signal level.

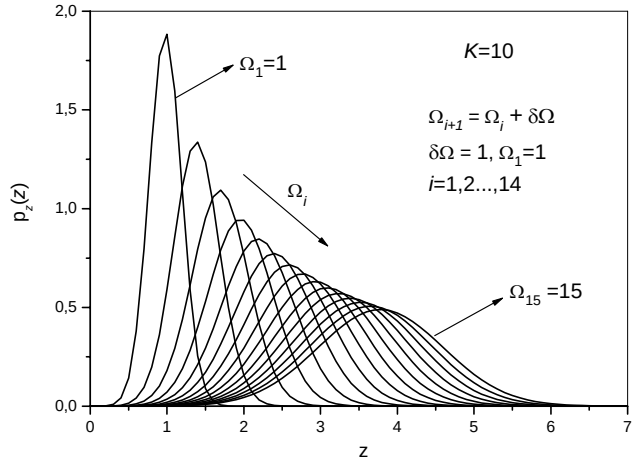

Fig. 1 The PDF dependance from z with parameter Ω, and Rician *K*-factor constant

We analyzed a PDF depenadance Fig 1. from the *z* variable with Ω like parameter and for constant value of Rician *K*-factor ./K=10, Ω=1÷15/. The PDF maximum decreasing with increasing the Ω. Also, it is obviouse that these distributions could be analyzed through the family of curves with Ω like the parameter of the family. We presented this family in log-log coordinates too Fig 2., and analysed the locations of the PDF's maximum for the different values of z in both systems.

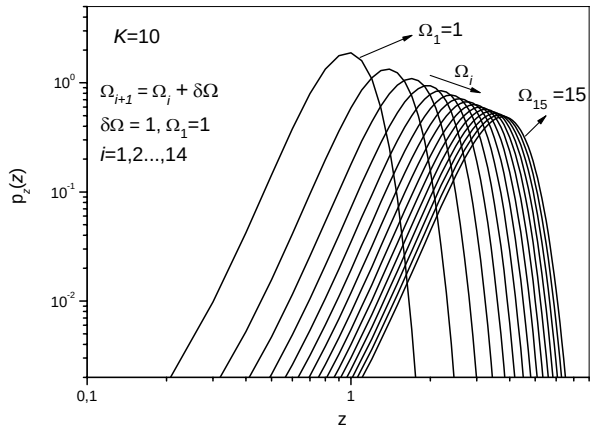

Fig. 2. The PDF dependence from z with Ω parameter and constant Rician *K*-factor in log-log coordinates

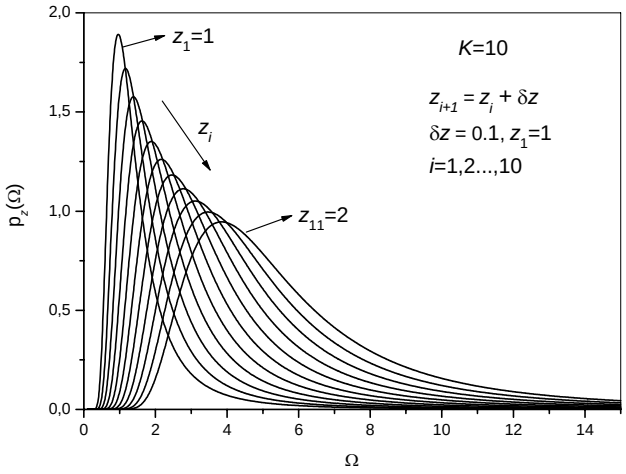

Fig. 3 The PDF dependance from Ω with parameter z, and K=10

We analyzed a PDF depenadance Fig 3. from the Ω variable with *z* .like parameter and for constat value of Rician *K*-factor ./K=10, z=1÷2/. The PDF maximum decreasing with increasing the *z*. Also it si obviouse that these distributions presents the family of curves with *z* like the parameter of the family. We presented this family in log-log coordinates too Fig 4, and analysed the locations of the PDF's maximim of the different values of Ω in both systems.

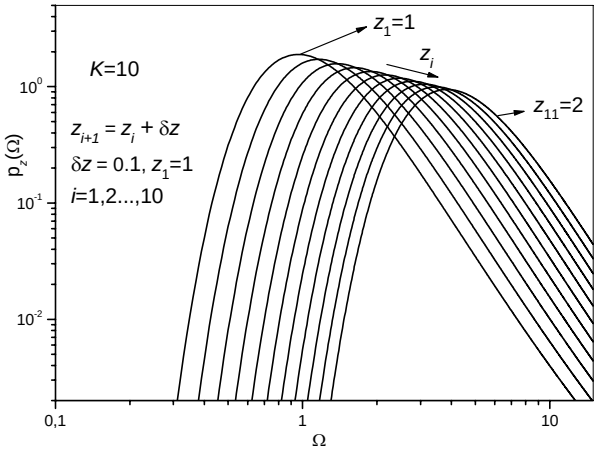

Fig. 4. The PDF dependance from z with parameter Ω, and and constant Rician *K*-factor in log-log coordinates

III. DISCUSSION

The maximum of PDF's are located on the envelope of the curve family. These envelopes could be approximated by exponential function Figs 1 and 3, or straight line in log-log coordinates Figs 2 and 4. The envelope existences enable to treat the PDF's like particular solutions of some differential equation, corresponding to a specific value of the equation free parameters. Also, numerical analysis Figs 2 and 4, confirms that beside the particular solutions, exist the singular solutions too, which present the above mention envelope of the analyzed curves family. We determined the envelope equations by graph-analytical methods. The envelope equations in the log-log coordinate for the parameters of the

curves families, Figs 2 and 4, have been approximated as (4) and (5) respectively:

$$\log(\max p_z(z)) = k_1 \log z + n_1 \quad (4)$$

$$\log(\max p_z(\Omega)) = k_2 \log \Omega + n_2 \quad (5)$$

The importance of the Rician distribution according the Shannon theory [13], made us to analyze the integral properties of Rician PDF from parameters, where are PDF treated, like we already mention, as particular solutions of first order PDE (partial differential equation) with the parameters of distribution like variables. Also, it means that the PDF could be analyzed like particular integral of differential equation for specific values of parameters. On the other side the curves family envelope shows that initial differential equation has singular solution, which existence could be used during the analysis of different conditions in the information chain with or without combiner.

The dependency of Ricean PDF versus z and Ω is presented by three-dimensional graph, as shown on Figure 5.

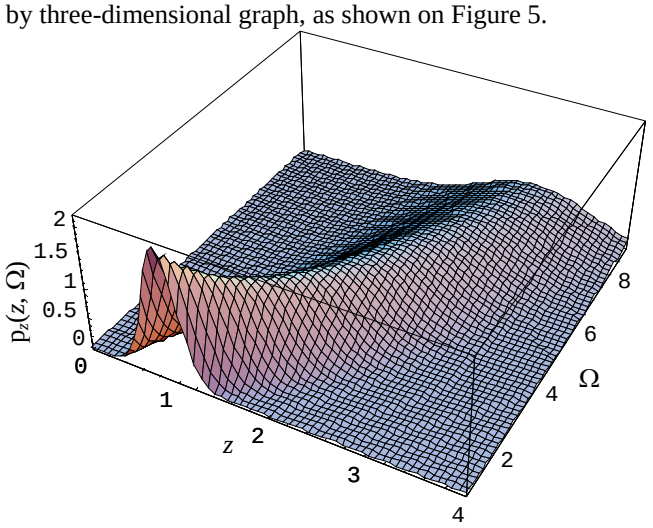

Fig. 5. The 3D view of Rician PDF

So the approach to envelope like singular solution of the PDF, concerning the empirical conditions of PDF determining, enable to a better view on the physical process and nature of fading. The fading analysis from the physical viewpoint needs a forming of particular differential equations with information entropy, which roles lie in relating conditions in one region to those in another, through a recursive process which allows us to progressively work out the solution from one place to another, a little bit at a time. The framework is prescribed by the differential equation, but the information which is to be relayed from one place to another is contained in the boundary conditions.

These remarks could be used in modeling of fading process, and the designed process of OBE and RSE hardware by providing very high date transfer rates in circumstances where minimizing latency in communication and isolating relatively small communication zones. The designed of the hardware for *OBE* and *RSE* units and many physical process and phenomena in high speed integrate circuits such as a peak noise voltage, varying load impedance, etc., based on one this approach, will result in the optimal relations between the system performance and design parameters in the various communications conditions as well as highway traffic conditions

IV. Conclusion

The importance of the Rician distribution according the Shannon theory, made us to analyze the integral properties of Rician PDF from parameters, where are PDF treated, like we already mention, as particular solutions of first order PDF (partial differential equation) with the parameters of distribution like variables. We determined the envelope equations by graph-analytical methods. The envelope equations in the log-log coordinates for the parameters of the These remarks could be used in modeling of fading process, and the designed process of OBE and RSE hardware by providing very high date transfer rates This approach could be use in the analysis of the other physical processes involved in the radio diffusion, optoelectronic and physics generally.

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